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Continuation of 3D Subsurface Well Data Analyses and 3D GIS for the Ventura Basin, California

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Abstract

In the Ventura basin, a series of active faults accommodate high rates of oblique crustal strain and represent a significant seismic hazard. The 1994 M6.7 Northridge earthquake occurred on a blind, south-dipping fault that is considered part of this same active fault and fold system that extends into the Ventura basin and offshore Santa Barbara Channel. To improve our understanding of how such faults and folds develop in oblique convergence, and to test the reliability of 2D models to predict 3D subsurface structure, we acquired a unique 3D dataset for the Ventura basin provided by the Ventura Basin Study Group (VBSG) derived from nearly 1200 correlated deep-penetration wells. The wells vary in depth from 1 to 5 km. Many of these wells drill active fault and fold structures associated with major fault systems, including the San Cayetano, Oak Ridge, and Santa Susana faults. The VBSG maps and cross sections are now available to the entire research community from our website at **http://www.crustal.ucsb.edu/hopps**.

We have been using the VBSG dataset, in combination with seismicity, seismic reflection, and offshore well data, to develop improved 3D structure contour maps of specific stratigraphic (time) horizons that extend across the basin and into the Santa Barbara Channel. 3D map restoration of these faulted and folded surfaces provides an independent estimate of the finite strain field, and by evaluating different horizons, the evolution of the strain field with time (and thus fault slip rates) can be determined. Preliminary results indicate that—in addition to uplift, folding, fault offset, and block rotation—significant crustal shortening is accommodated by isostatic subsidence, sediment compaction, and other types of footwall deformation. Moreover, this subsidence is not necessarily restricted to just the basins, but affects uplifting regions as well. In the Ventura basin, subsidence and compaction are significant and locally reach a maximum of ~3 mm/yr. These effects must be properly accounted for in the regional analysis of both geologic and geodetic data, or estimates of fault slip and seismic hazard could be incorrectly determined.

Introduction

The western Transverse Ranges are one of the most active tectonic regions of the world. Active convergence and rapid subsidence across the Ventura basin has produced uplift rates that exceed 10 mm/yr and one of the thickest sections of Plio-Pleistocene strata ever found [*Yeats et al.*, 1994]. Geologic and geodetic data indicate that the Ventura basin currently accommodates high rates of oblique crustal strain [*Donnellan et al.*, 1993; *Huftile and Yeats*, 1995] including components of regional tectonic rotation. Significant amounts of oblique convergence (up to 7 mm/yr) have also been documented across the eastern Santa Barbara Channel [*Larsen et al.*, 1993]. The 1994 M6.7 Northridge earthquake occurred on a blind, south-dipping fault beneath the San Fernando Valley that is considered part of the active fault and fold system that extends westward into the Ventura basin and eastern Santa Barbara Channel [*Yeats and Huftile*, 1995] (**Figure 1**, top). This fault system is currently active at the microearthquake level [*Ziony and Jones*, 1989; *O'Connell*, 1995]. The Santa Barbara–Ventura region is currently ranked as having the third largest seismic hazard (behind San Francisco and Los Angeles) of any metropolitan area in the conterminous United States [*US Geological Survey*, 1998].